



# Biofuels and the United States Measurement System





Clare Allocca

Chief, United States Measurement System Office

**Technology Services** 

National Institute of Standards and Technology

USMS Nano-EHS Webinar June 9, 2009











## **Objectives**

- What is the United States Measurement System (USMS)?
- What does it mean to Assess the USMS?
- What is the Measurement Knowledge Hub?
- Measurement Needs and Solutions in the Biofuels sector
- Discussion of Opportunities
- The Path Forward







Clare Allocca is the Chief of The United States Measurement System (USMS) Office at the National Institute of Standards and Technology (NIST). She has 23 years of experience in the conduct of advanced materials, surface engineering, and measurement technology R&D, program management, strategic planning, customer engagement and process development/implementation.

She holds Bachelor of Science Degrees in Materials Science and

















Engineering and Geochemistry from the Massachusetts
Institute of Technology; a Master of Science Degree in Ceramic
Engineering from the University of Illinois at UrbanaChampaign; and an Executive Master of Science Degree in the
Management of Technology from the University of Pennsylvania
(Wharton Business School / School of Engineering). Before
joining NIST, she was a Senior Materials Engineer for Pratt &
Whitney engaged in the development of advanced ceramic
composites for jet engines.





Chris Clark is a Senior Scientist with Energetics, Incorporated. His 17 plus years of experience includes measurement science related to the development and operation of geophysical instruments used in the oil/gas and environmental fields, remediation engineering, and renewable energy consulting. Mr. Clark currently provides technical and analytical support for both private and public sector clients, primarily within the renewable energy sectors.

He has a B.S. in Environmental Science from Sierra Nevada College and an M.S. in Environmental Science and Policy from Johns Hopkins University.



















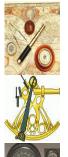












## Yes

Poll: Are you Aware of the existence of

the 2007 USMS Assessment Report?







#### **United States Measurement System**

United States Measurement System

#### What?

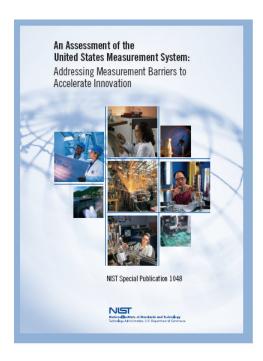
The set of measurement solution providers and users, and the relationships among them

#### Why?

- Promote U.S. innovation and industrial competitiveness via
  - Increased effectiveness and efficiency in developing and deploying measurement solutions

#### How?

 By identifying and fostering efforts to address unmet measurement needs



- Documents 723 measurement barriers to innovation
- Covers 11 industry sectors
- Over 1000 contributors from industry, academia, and other government agencies





# NIST's Other Role in the USMS: the USMS Office

#### Access

- Develop Infrastructure for Measurement Needs and Solutions Submission
- Increase Awareness of USMS Importance

#### **Assessment**

- Examine USMS from Multiple Vantage Points
- Perform Focus Area Assessments
- Enhance Methodologies
- Provide Tools to Enable Others to Assess

#### Action

- Stimulate Pursuit of Unmet Measurement Needs
- Develop Measurement Knowledge Hub as Platform to Maximize Effectiveness and Efficiency





#### Action: What's in it for me?

- \* Inform strategic decision making
- \* Accelerate development of critical measurement solutions
  - \* Identify and authenticate existing measurement needs & solutions
- \* Customer Input (e.g. Needs, Priorities)
- \* Identify opportunities / Educate / Communicate

# Basis for Assessment: Authenticated Measurement Needs (MN)

- MN Template
- Tags / Indicators
  - \* MN Characteristics that may be used to compare MNs
- Authentication
  - \* Evidence of a significant number of interested users for any measurement solution that is developed



# Case Study Measurement Need: *Identification of Biotechnology-Derived Crops*

Technological Innovation at Stake: U.S. agricultural products companies have developed insect-resistant and herbicide-tolerant varieties of maize, soy and cotton developed through genetic engineering, and in 2005 U.S. farmers planted 123 million acres of these crops. The EU, China, Japan, and other U.S. trading partners have put labeling requirements in place that can exclude biotech crops in these markets. Companies register and obtain approval for the genetic modifications used with importing countries. Importation of registered crops is allowed with no labeling requirement while those crops, and products made from them, with content above the threshold must be labeled. Variation in test results at ports of entry of importing countries can have adverse economic effects on U.S. producers.

*Economic Significance of Innovation:* ...Exports of biotech crop containing food and grain shipments are subject to approval and labeling regulations of importing countries...4000-ton grain exports have been rejected based on differing test results between producing and importing countries





## Case Study Measurement Need: *Identification of Biotechnology-Derived Crops*

Technical Barrier to the Innovation: ...Although dual infrastructure for commodity crops requires separate storage and transport facilities, mixing of grain from many sources occurs and drives the need for determination of biotech crop composition of individual shipments. Inconsistency of measurement results at various points between the farmer, the exporter and the final consumer have sufficient levels of variation to fuel marketplace confusion. Measurement systems having higher reliability are needed.

*Measurement-Problem Part of Technical Barrier:* Robust testing protocols require (1) knowledge of the genetic sequence of the DNA inserted in the genome,...and (2) the ability to detect that sequence with sufficient sensitivity and accuracy...





# Case Study Measurement Need: *Identification of Biotechnology-Derived Crops*

- Stage of Innovation Where Barrier Appears: Market
- Potential Solutions to Measurement Problem: 1) International harmonization agreements on the use and development of robust measurement protocols. 2) Development of new measurement tools that do not rely on DNA amplification. 3) Appropriate reference materials for calibration of the DNA concentration and validation of method performance.





# Using Measurement Needs to Assess the State of the USMS

- Gather Authenticated Measurement Needs
- Analyze and Aggregate
  - \* Sets of Measurement Needs
  - \* Roadmaps / Key Documents
- Apply Expertise
  - \* Derive Inferences / Findings
  - \* Authenticate Inferences / Findings

Phase I Assessment: Over 700 measurement needs were identified in 11 sector/technology areas, with input from 322 individual measurement needs and 162 technology roadmaps







## **Assessment: Current Focus Areas**

- Nanotechnology Environmental, Health & Safety
- Alternative Energy
  - \* Biomass
  - \* Hydrogen / Fuel Cells
  - \* Infrastructure / Smart Grid
  - \* Solar / Photovoltaic
  - \* Nuclear
- Core Metrology
- Sensors for Civil Infrastructure
- Carbon Mitigation Strategies
- Biosciences



## Measurement Knowledge Hub: Current Operational Features

- Measurement Needs
  - \* Search
  - \* Entry
- Blog: A Measure Above
- Forums
- Webinars

http://usms.nist.gov



















## http://usms/nist.gov

(Clare will control the website navigation at this point so that all can see what I am doing)





#### What's Next?

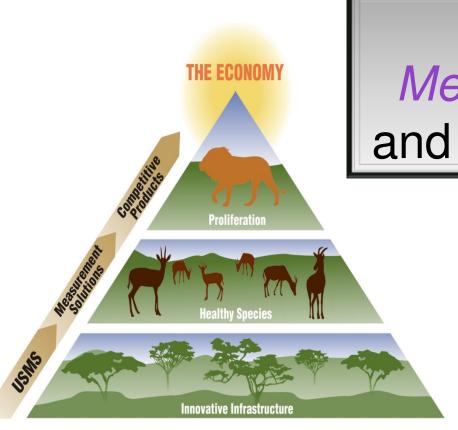
- Provide New Functionalities for the Measurement Knowledge Hub
- Release Assessment Report #2 (2009)
- Continue to Pursue Resources for Unmet Critical Measurement Needs
- Continue to Facilitate Action to Address Measurement Needs
- Continue to Promote USMS Access and Awareness







## The US Measurement System...



#### ...where

Measurement Science and Innovation converge

For more information:

Website: <a href="http://usms.nist.gov">http://usms.nist.gov</a>

Contact: Clare Allocca, Chief, USMS Office,

Clare.allocca@nist.gov/301-975-4359

























Preliminary Biofuel
Measurement
and Standard
Needs Analysis

Chris Clark June 9, 2009



## **Agenda**









#### Introduction

Goal of the project is to identify a preliminary list of biofuels measurement and standards needs.

Why?





### **Objectives**

- ✓ What are the measurement needs associated with biofuels?
- ✓ What are the challenges/barriers?
- ✓ Who can help to address these challenges?







#### **Overview**

- Data gathering and review
- Identification of biofuel sector subcategories
- ✓ Input of preliminary measurement needs (MNs)in database
- ✓ Analysis of the MN dataset





#### **Literature Review**

- ✓ Total of 30+ documents reviewed
  - Biofuel/Biomass Roadmaps
  - Industry Reports
  - Agency Program Plans
  - Conference Presentations
  - Technical Papers





#### References

Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda A Research Roadmap Resulting from the Biomass to Biofuels Workshop Sponsored by the U.S. Department of Energy DOE/SC-0095, Office of Science, Office of Biological and Environmental Research, Genomics:GTL Program Office of Energy Efficiency and Renewable Energy, Office of the Biomass Program, Publication Date: June 2006.

http://genomicsgtl.energy.gov/biofuels/b2bworkshop.shtml

- Roadmap for Biomass Technologies in the United States, Biomass Research and Development Technical Advisory Committee, Washington D.C., December 2002. <a href="http://www.brdisolutions.com/Site%20Docs/Final%20Biomass%20Roadmap.pdf">http://www.brdisolutions.com/Site%20Docs/Final%20Biomass%20Roadmap.pdf</a>
- The North Carolina Biomass Roadmap: Recommendations for Fossil Fuel Displacement through Biomass Utilization, May 2007. http://www.engr.ncsu.edu/ncsc/bioenergy/docs/NC\_Biomass\_Roadmap.pdf
- Biomass Multi-Year Program Plan, Office of the Biomass Program Energy Efficiency and Renewable Energy U.S. Department of Energy, Washington D.C., March 2008 http://www1.eere.energy.gov/biomass/pdfs/biomass\_program\_mypp.pdf





#### References cont.

- The Technology Roadmap for Plant/Crop-Based Renewable Resources 2020 Research Priorities for Fueling a Vision to Enhance U.S. Economic Security Through Renewable Plant/Crop-Based Resource Use, Renewables Vision 2020 Executive Steering Group, 1999.
  - http://www1.eere.energy.gov/biomass/pdfs/technology\_roadmap.pdf
- Roadmap for Bioenergy and Biobased Products in the United States, Biomass Research and Development Technical Advisory Committee, Biomass Research and Development Initiative, October 2007.

  <a href="http://www1.eere.energy.gov/biomass/pdfs/obp\_roadmapv2\_web.pdf">http://www1.eere.energy.gov/biomass/pdfs/obp\_roadmapv2\_web.pdf</a>
- Roadmap for Agriculture Biomass Feedstock Supply in the United States, Sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Biomass Program, Washington D.C., November 2003. <a href="http://devafdc.nrel.gov/pdfs/8245.pdf">http://devafdc.nrel.gov/pdfs/8245.pdf</a>
- Clean Cities Roadmap, US Department of Energy, Energy Efficiency and Renewable Energy, Washington D.C., 2004.
   <a href="http://www.mga-cleancities.com/pdf/Roadmap.pdf">http://www.mga-cleancities.com/pdf/Roadmap.pdf</a>





#### References cont.

- Thermodynamic Data and Measurements for Biofuels (Presentation), Robert N. Goldberg, Biochemical Science Division, NIST, A Symposium on Biofuels: Measurements and Standards to Facilitate the Transition to a Global Commodity; Cosponsored by NIST, and INMETRO, June 2007.
  - http://www.nist.gov/oiaa/goldberg.pdf
- Measurement and Standards for Biofuels: Enabling a Transition from Petroleum as a Vehicular Energy Source, Hratch G. Semerjian, NIST, Joint INMETRO-NIST Workshop Rio de Janeiro, September, 2006.
  - www.inmetro.gov.br/metcientifica/palestasBio/Petroleum.ppt
- Biomass as a Feedstock for Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply, Oak Ridge National Laboratory TN, April 2005.
  - http://www1.eere.energy.gov/biomass/pdfs/final\_billionton\_vision\_report2.pdf
- Accelerating Innovation in 21<sup>st</sup> Century Biosciences: Identifying the Measurement, Standards, and Technological Challenges (Draft), US National Institute of Standards and Technology, 2009.





#### References cont.

Thermochemical Ethanol via Indirect Gasification and Mixed Alcohol Synthesis of Lignocellulosic Biomass, Technical Report NREL/TP-510-41168, National Renewable Energy Laboratory, TN, April 2007.

http://www.nrel.gov/docs/fy07osti/41168.pdf

Measurement and Standards Needs for an Advanced Biofuels Economy (Presentation), Willie E. May, NIST, A Symposium on Biofuels: Measurements and Standards to Facilitate the Transition to a Global Commodity; Cosponsored by NIST and INMETRO, June 2007.

http://www.nist.gov/oiaa/WillieMay.pdf

Breaking the Chemical and Engineering Barriers to Lignocellulosic Biofuels:
 Next Generation Hydrocarbon Biorefineries, A Research Roadmap for Making Lignocellulosic Biofuels a Reality, University of Massachusetts, Amherst, March, 2008.

http://www.ecs.umass.edu/biofuels/Images/Roadmap2-08.pdf

National Biofuels Action Plan, Biomass Research and Development Board, U.S. Department of Agriculture (USDA) and U.S. Department of Energy (DOE), Washington D.C., October 2008.

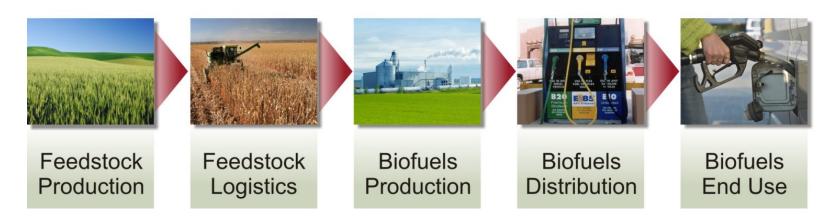
http://www1.eere.energy.gov/biomass/pdfs/nbap.pdf





## **Subcategory Development**

#### **Biofuels Supply Chain**







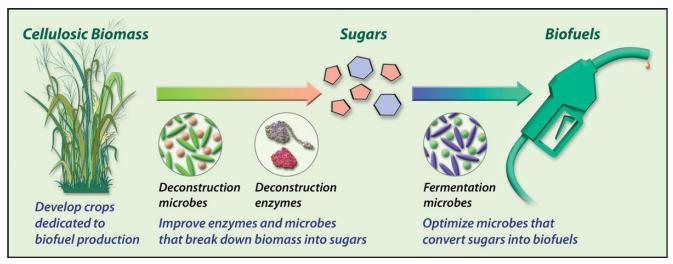
#### Subcategory Development Cont.

✓ The Energy Independence and Security Act of 2007 (EISA) requires use of 36 billion gallons of renewable transportation fuels in the U.S. by 2022. Of that quantity, 16 billion gallons must be cellulosic biofuels. Ethanol from corn is capped at 15 billion gallons.





#### Subcategory Development Cont.



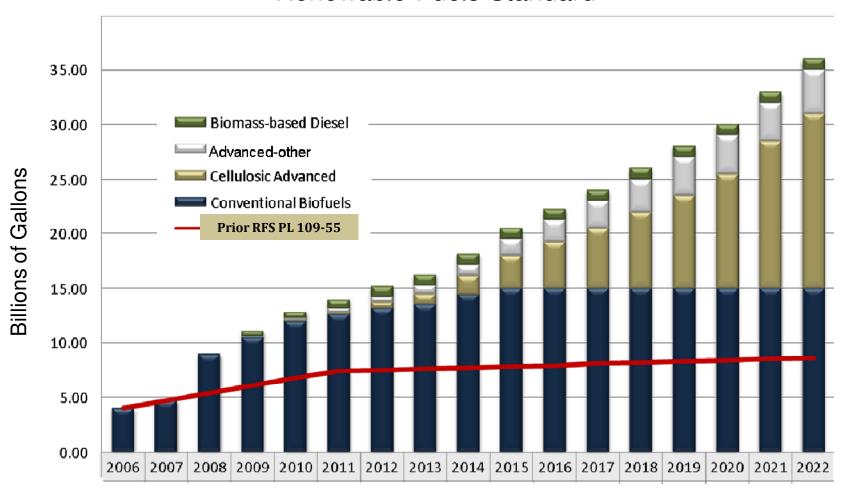
TYPICAL BIOCHEMICAL CELLULOSIC BIOFUEL PROCESS

Thermochemical Processes: gasification of biomass then conversion to fuels; pyrolysis to produce bio-oils; others





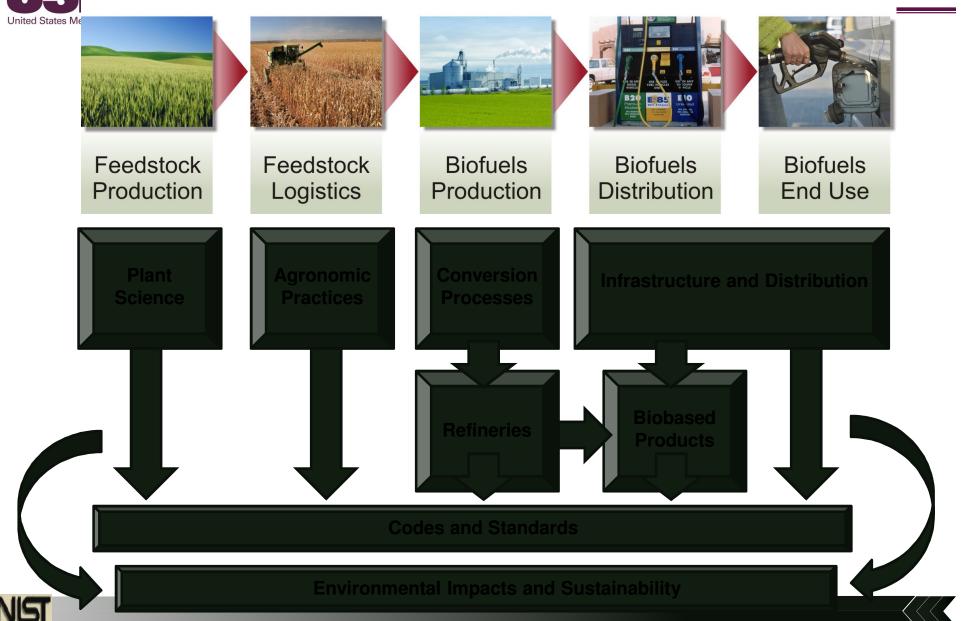
## Energy Independence and Security Act (EISA) Renewable Fuels Standard







#### **Biofuels Supply Chain**





## **Biofuels Subcategories**

## Feedstacks Plant Science · Agronomic Practices **Conversion Processes** Refineries **Biobased Products** Infrastructure and Distribution **Codes and Standards Environmental Impacts and** Sustainability





### **Biofuels Methodology: Database**

- ✓ Input the preliminary MNs into the database
  - Descriptions
  - Tags (standardized keywords)
- ✓ Database capabilities:
  - House MNs in a central location
  - Quickly analyze the distribution of MNs within the biofuel sector and across various economic sectors
  - Production of reports related to MNs





## **Biofuels Methodology: Database**

- √ Tags assigned to each MN allow for the grouping and analysis of the biofuel supply chain.
- ✓ Tag categories include:
  - Subcategory
  - Stage of technology
  - Measurand (property to be measured)
  - Measurement barrier
  - Measurement solution
  - Solution providers





## **Preliminary MNs: Overview**

- ✓ Subcategories review
- ✓ Recurring themes in preliminary MNs
- ✓ Analysis of preliminary MN assessment
- ✓ Feedback





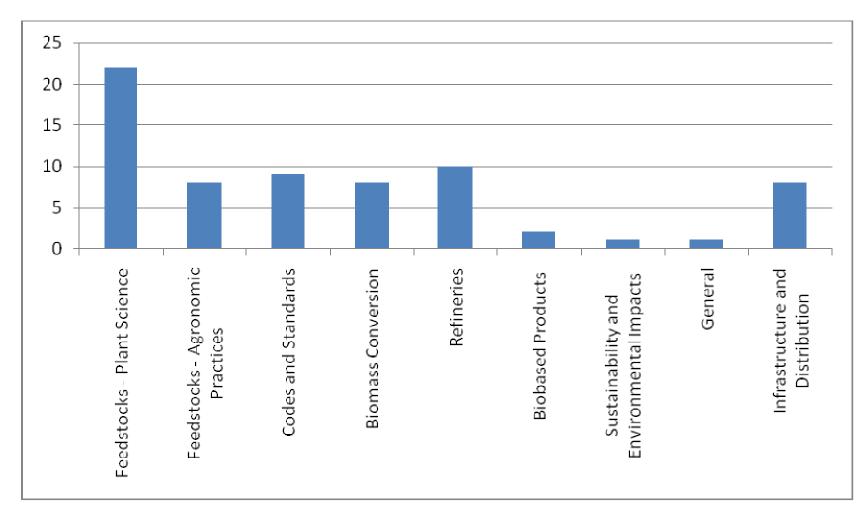
## **Biofuels Subcategories**

# Feedstacks Plant Science · Agronomic Practices **Conversion Processes** Refineries **Biobased Products** Infrastructure and Distribution **Codes and Standards Environmental Impacts and** Sustainability





## **Preliminary MNs: By Subcategory**







#### **Common Themes: Plant Science**

Plant science measurement needs are some of the most critical required to move next generation biofuels from the laboratory to production

- New measurement technology to visualize and track the biological processes
- Validation of models and reference data
- New characterization tools including new protocols, analytical methods, and measurement instruments
- DNA characterization of feedstocks







#### **Common Themes: Agronomic Practices**

Most measurement needs are centered around the requirement to supply logistics monitoring techniques to the farming industry.

- Location of the prime farming areas
- Identification of the best feedstock to grow on what land
- Methods to monitor the same feedstock type in different locations
- Methods to monitor feedstock quality through collection, storage, and transportation phases of the life cycle, etc.





# Common Themes: Conversion Processes and Refineries

Most measurement needs are centered around the fundamental knowledge needed to convert biomass to biofuel and integrate the process in biorefineries.

- Analytical studies on cost, performance, life-cycle emissions as well as scalability
- Technologies to handle complex control requirements
- Models related to transport, fluid and feed properties
- In-situ measurement techniques





# Common Themes: Infrastructure and Distribution

Infrastructure and distribution measurement needs are centered around the fundamental knowledge needed to safely and efficiently transport and dispense biofuels.

- Physical properties data including combustion, vapor pressure, viscosity, etc.
- Chemical fingerprinting techniques
- Remote monitoring techniques for pipelines, tanks, etc.
- Compatibility characteristics





## **Common Themes: Biobased Products**

A variety of measurement needs are required to address the replacement of petroleum-based products with biobased products.

- Variables associated with conducting an effective cost -benefit and life cycle analysis
- Toxicity and effects of by-products
- Online chemical composition measurements of each product
- Performance standards and benchmarks compared to petroleum based products





## **Common Themes: Sustainability**

Measurement needs associated with sustainable development of biofuels are required throughout the biofuel supply chain.

- Variables associated with effective life cycle analysis for each type of feedstock to enable fair comparison to oil
- Yield sustainability --- biomass replacement, water use, other resources
- Assessment of GHG emission reductions
- Recyclability of materials





#### **Common Themes: Codes and Standards**

A variety of analytical, documentary and harmonization efforts are needed to address code and standard issues.

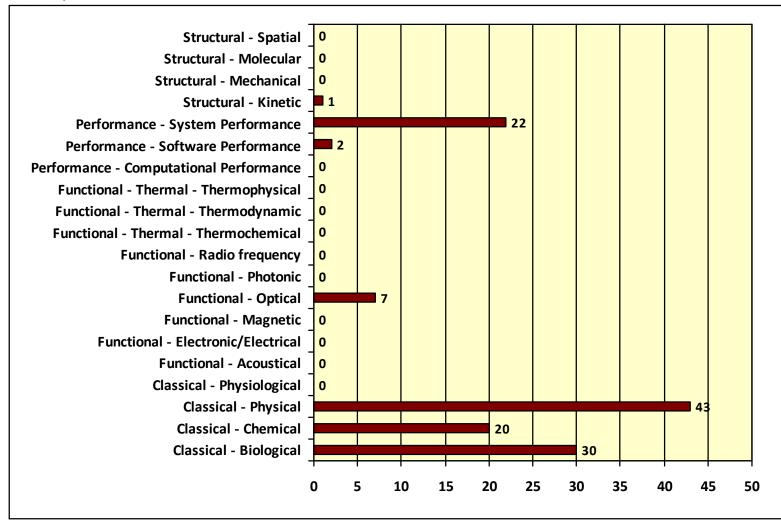
- New measurement technology to address stability, quality, and characterization of various forms of biomass and resulting biofuels
- Standards based on performance measurement that are independent of feedstock
- Extensive infrastructure measurement and associated techniques: reference materials, field methods, etc.
- Alignment and harmonization of codes and standards among local/states and national/international organizations







#### **Measurand Distribution**

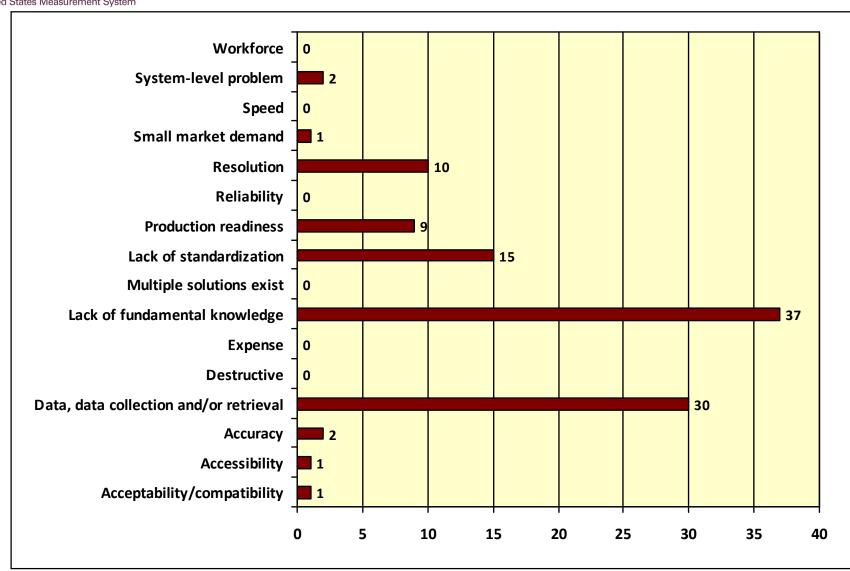


Measurand – Property or attribute being measured or characterized.





#### **Measurement Barriers**







### **Correlation Between Barriers and Stages of Technological Innovation**

	Measurement Solution Barriers															
Stage of Technological Innovation	Acceptability/compatibility	Accessibility	Accuracy	Data, data collection and/or retrieval	Destructive	Expense	Lack of fundamental knowledge	Multiple solutions exist	Lack of standardization	Production readiness	Reliability	Resolution	Small market demand	Speed	System-level problem	Workforce
Basic Research			1	19			25			3		9				
Applied Research		1	2	23			30		3	4		10			2	
Production		1	1	20			23		13	6		5	1		2	
Market	1	1	1	7			9		13	5		1			1	
End-Use	1			3			4		8	3						





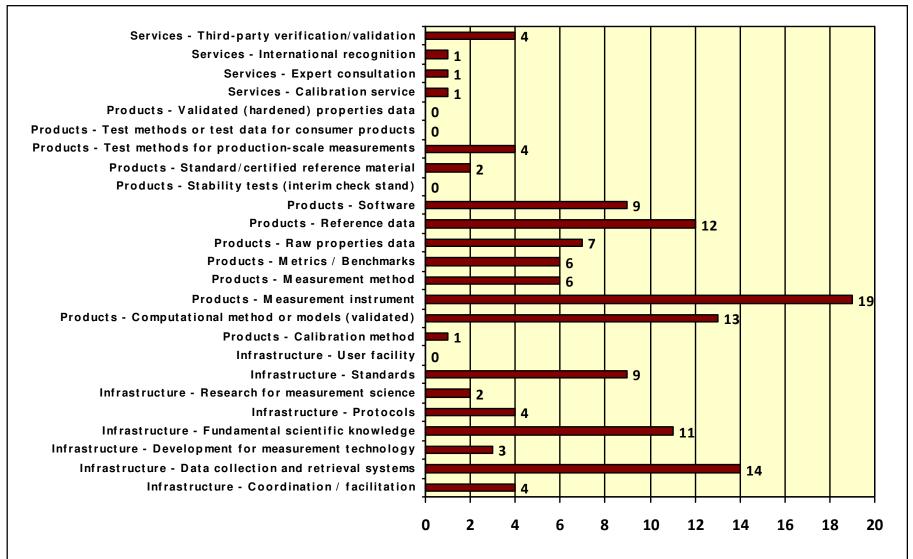
# **Correlation Between Barriers and Measurement Solution Providers**

ent System																
		Measurement Solution Barriers														
Measurement Solution Providers	Acceptability/compatibility	Accessibility	Accuracy	Data, data collection and/or retrieval	Destructive	Expense	Lack of fundamental knowledge	Multiple solutions exist	Lack of standardization	Production readiness	Reliability	Resolution	Small market demand	Speed	System-level problem	Workforce
Commercial Calibration Service Providers																
Component Suppliers		1		4			6		2	4		2				
Engineering Management/ Consulting Firms/A&E Firms			1	5			5		6	2					1	
nstrument Suppliers		1		8			7		3	5		5				
Material Suppliers				1			1		1	2						
Small Business/Inventors				1			1						1			
Software Developers				4			3		3	1		1				
Sovernment Laboratories and Agencies			1	16			22		2	1		9			1	
Calibration Laboratories				2			1			1						
Contractor R&D Labs-for-Hire			1	8			11			2		3	1			
ndependent Testing/ Certification Laboratories			1	4			3						1			
Industrial R&D Laboratories				7			11		1	1		4				
Testing Laboratories				10			13		2	1		2				
National Measurement Institute		1		3			5		3	4		2				
Standards Development Organizations (SDO)	1			7			8		10	4						
Universities			2	18			25		1	2		9			1	
ndustry Consortium/Partnershin		1		14			15		5	3		4	1		1	





#### **Measurement Solutions**







## **Summary of Preliminary Observations**

- There is significant research underway to understand the fundamental properties of cellulosic biomass.
- Many of the bottlenecks in deployment of new biofuels remain at the basic and applied research phases.
- Government laboratories and industry partnerships are key to solving many of the measurement barriers, including the harmonization of codes and standards.
- The biofuel supply chain is complex and a concerted effort will be required to achieve large scale production of biofuel.





#### **Preliminary MNs and Next Steps**





















- Ranking/prioritizing of preliminary biofuel MNs
- Joining USMS web community
- Comment on forum posts
- Author new MNs
- Refine preliminary biofuel MNs

#### Next Steps

- Collect comments on preliminary biofuel MNs
- Authenticate preliminary biofuel MNs
- •Grow the list of biofuel MNs with help from the biofuel energy community
- Publish report discussing this sector-specific assessment



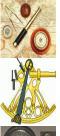
















# Poll: Are you willing to coauthor a Measurement Need?

Yes

No





# **Biofuels Community: The Path Forward**

- Grow list of MNs
- Assess USMS
- Authenticate MNs and Assessment Findings
- Develop Path to Critical Measurement Solutions
- Follow-on Forums, Webinars and/or Live Workshops

http://usms.nist.gov



















# Poll: Would you be interested in a follow-on Webinar?

Yes

No















# Poll: Are you interested in participating in a Working Group on Biofuels Measurement Needs?

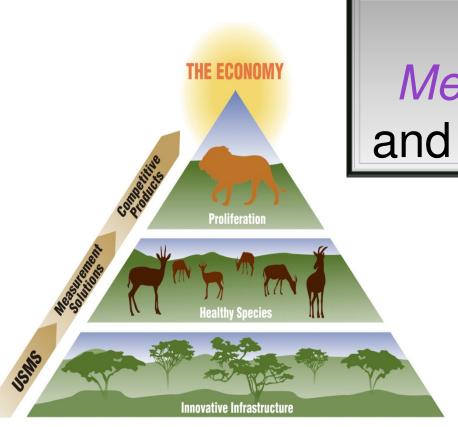
Yes

No





## The US Measurement System...



#### ...where

Measurement Science and Innovation converge

For more information:

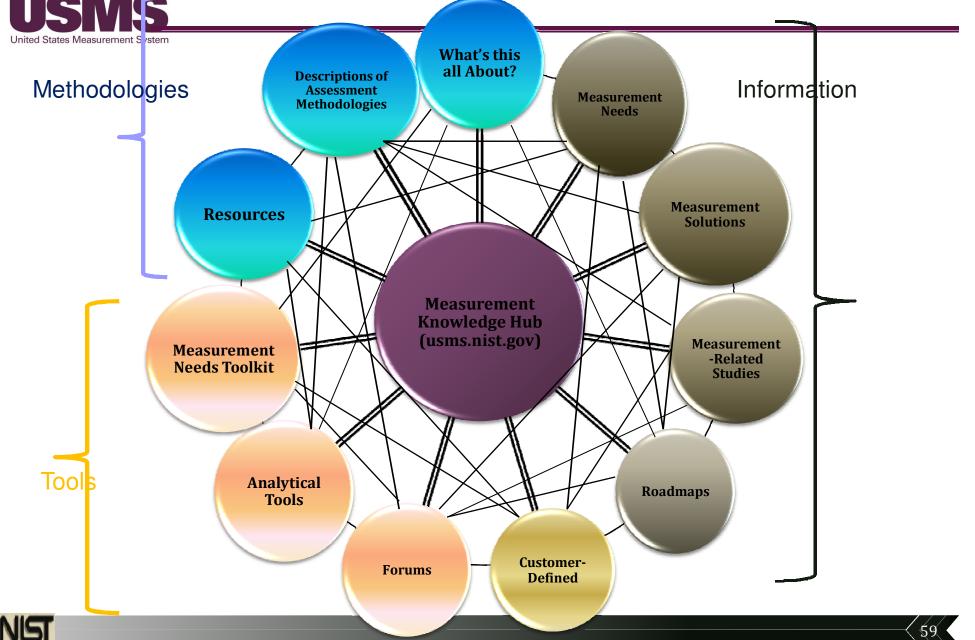
Website: <a href="http://usms.nist.gov">http://usms.nist.gov</a>

Contact: Clare Allocca, Chief, USMS Office,

Clare.allocca@nist.gov/301-975-4359



# Measurement Knowledge Hub (MKH): A Web-based Meeting Place for all Things Measurement





# Measurement Knowledge Hub: Future Operational Features

- Measurement Needs
  - \* Analysis
- Roadmaps Database
- Measurement Solutions
- Measurement Needs & Solutions Toolkit
- Assessment Reports